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How to Perform a Literature Review with Free and Open Source Software

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As it provides a firm foundation for advancing knowledge, a solid literature review is a critical feature of any academic investigation. Yet, there are several challenges in performing literature reviews including: i) lack of access to the literature because of costs, ii) fracturing of the literature into many sources, lack of access and comprehensive coverage in many databases and search engines, and iii) the use of proprietary software lock-in strategies for bibliographic software, which can make porting literature reviews between organizations cumbersome and costly. These challenges often result in poor quality literature reviews completed by a single researcher unfamiliar with the approaches to the same research in other sub-fields and static reviews that are often lost to the scientific community. In this paper, an open source approach will be expanded to the application of improving the quality of literature reviews by providing best practices. Although there are many types and goals of literature reviews, it is found that all of them can be improved using a tool chain of free and open source software (FOSS) and methods. Specifically, this paper will provide a clear framework for i) comprehensive searching and obtaining access to the literature, ii) the use of FOSS for all steps including browsing, bibliographic software, and writing and iii) documenting a literature review to encourage collaboration of a dynamic document that lives into the future. This approach solves the current challenges of literature reviews and provides benefits of lower labor and economic costs, improved researcher control, and increased potential for collaboration. Finally, the challenges of using this approach and methods to overcome them are reviewed and future work is described.

A solid review of the prior relevant literature is a critical feature of any academic investigation as it provides a firm foundation for advancing knowledge (Webster & Watson, 2012). Without a good literature review, a researcher cannot perform significant research in any field (Boote & Beile, 2005) whether it is for a research article, a critical review for coursework (Jesson & Lacey, 2006) or a dissertation (Randolph, 2009). Levy and Ellis argue that an effective literature review should: i) methodologically analyze and synthesize quality literature, ii) provide a foundation to a research topic and methodology, and iii) demonstrate that the proposed research would advance the research field's knowledge-base (2006). Literature reviews help researchers avoid redundancy, establish a context and significance of their research topic, identify primary methodologies in the field and determine what needs to be done to solve research problems (Hart, 1998). A well-executed literature review can also be a legitimate and publishable document and can be some of the most valuable (and cited) type of scholarly work if it is a systematic literature review (Cooper, 1988a; Bettany-Saltikov, 2012; Boote & Beile, 2005).

There are several challenges in performing literature reviews. First, some scholars have difficulty gaining access to all of the literature itself due to the collateral damage of intellectual property (Boldrin & Levine, 2008). The unintended consequences of copyright restrictions and paywalls narrow access to the peer-reviewed literature (Lewis, 2012) to the point that even Harvard University is challenged to pay for it (Sample, 2012). Researchers simply cannot review what they cannot read. Secondly, there is also a fracturing of the

literature into many topical journals, interdisciplinary journals, and various society proceedings, which makes it more challenging to perform a comprehensive literature review. This is a particular problem in some fields such as in engineering, which has historically suffered from weak literature reviews (Shaw, 1995) and can often be artificially arranged in academic and research society silos. For example, electric battery-related research is published in IEEE, ACS, MRS, and ASME societies as well as conventional journals. Few scholars are members of all of the relevant organizations. Coupled to this there are also challenges related to the lack of comprehensive coverage of the literature in many databases, lack of access to all databases, the poor quality of search engines and the difficulty of getting consistent results from them (Budgen & Brereton, 2006). Finally, the use of proprietary software lock-in strategies (Zhu & Zhou, 2012) for bibliographic software such as EndNote, Reference Manager, Papers, etc. raises costs and can make porting literature reviews between universities, between firms, and from universities to industry cumbersome and costly. For example, a social science Ph.D. student using a 'free' version of a proprietary software tool while at university A may create a detailed literature review database on her thesis topic. However, she may not be able to access upon graduation even if employed as a professor at university B, without paying for the software costs or subscriptions not supported by her new employer. These three challenges often result in poor quality literature reviews completed by a single researcher unfamiliar with the approaches to the same research in other sub-fields and static reviews that are often lost to the scientific community as only components of a review are used in a standard research article.

In this paper an open source approach will be described to overcome many of these challenges in reviewing the literature. An open source approach is well-established to provide improved product innovation over proprietary techniques of technical development (Deek, & McHugh, 2007; DiBona & Ockman, 1999; Lakhani & Von Hippel, 2003; Raymond, 1999; Söderberg, 2015). This has been proven most effective at software development because free and open source software (FOSS) provides open innovation and diversification (Colombo, et al., 2014; Henkel, et al., 2014; Dodourova & Bevis, 2014), organizational innovation (Alexy, et al., 2013), cumulative innovation (Boudreau, & Lakhani, 2016), development efficiency (Hienerth, et al, 2014), avoids redundant work (Årdal & Røttingen, 2016), the quality of code is superior (Söderberg, 2015), and it encourages more creativity (Martinez, 2015). The open source approach is now also gaining traction in free and open source hardware most notably for scientific tools (Baden et al., 2015; Coakley & Hurt, 2016; Pearce, 2013). Regardless of the technology, open source is cost effectiveness for use (Pearce, 2013; Petch, et al., 2014; Riehle, 2007; Wittbrodt, et al., 2013) and development (Hawkins, 2004; Pearce, 2015a; 2015b; 2017). In this paper, the open source approach will be expanded to the application of improving the quality of literature reviews. Although there are many types and goals of literature reviews (Cooper, 1988b), all of them can be improved using a tool chain of free and open source software and methods. Specifically, this paper will provide a clear framework for i) comprehensive searching and obtaining access to the literature, ii) the use of FOSS for all steps including browsing, bibliographic software, and writing and iii) documenting a literature review to encourage collaboration of a dynamic document that lives into the future.

Comprehensive Searching and Gaining Access to the Literature

Previously researchers were dependent on having paid access (normally through their institution) to one or more of the major proprietary repositories such as Web of Science, Engineering Village, Academic Onefile, ProQuest, Ulrichsweb, Scopus, Science Direct (Elsevier), Wiley Online Library, JSTOR, IEEE Xplore, ACS Publications, and EBSCO among others. Although costly these databases were often incomplete and biased. For example, Web of Science is biased towards science (instead of engineering), English language journals, against particular fields and disciplines and has extremely limited coverage of non-journal sources (Harzing, 2017). Today there a number of no cost academic search engines, which are summarized in Table 1.

As can be seen in Table 1, a number of the search engines specifically focus on open access articles, which are on the rise and constitute at least 28% of the literature (Piwowar, et al., 2017). In addition to these dedicated repositories and search engines shown in Table 1, the Directory of Open Access Journals also provides links to the open access publisher's websites that all have searchable and freely available open access

Table 1. No cost academic search engines for published papers and preprints.

Name	Website	Description
Comprehensive		
Academia	www.academia.edu	A platform for academics to share open access research papers and preprints. Over 61 million academics use the site.
Bielefeld University's Academic Search Engine (BASE)	www.base-search.net	More than 100 million documents with open access for 60% of the indexed documents.
Directory of Open Access Journals	doaj.org	A community-curated online directory that indexes and provides access to high quality, open access, peer-reviewed journals. 67 million articles are indexed.
Google Scholar	scholar.google.com	Reasonably comprehensive, indexes academic information from various online web resources
Microsoft Academic Research	academic.microsoft.com	Reasonably comprehensive, 172 million publications indexed
OSF PrePrints (Center for Open Science)	osf.io/preprints	Searchable preprints over a wide range of disciplines (contains 2.1 million).
Preprints (MDPI)	www.preprints.org	A platform dedicated to making early versions of research outputs available, including original research articles and reviews.
Science Open	www.scienceopen.com	Professional networking platform for scholars to enhance their research in the open with 40 million records.
Semantic Scholar (Allen Institute)	www.semanticscholar.org	An academic search engine that utilizes artificial intelligence methods to provide highly relevant results and novel tools to filter them with ease.
ResearchGate	www.researchgate.net	A social networking website for researchers. Contains more than 100 million publication pages.
Specialty		
Bioline International	www.bioline.org.br	Focused on public health, food and nutritional security, food and medicine and biodiversity
BioOne	www.bioone.org	Full-text database of more than 200 leading journals in the biological, ecological, and environmental sciences.
CERN Document Server	cdsweb.cern.ch	Articles, reports and multimedia content in high energy physics
Cornell's ArXiv	arxiv.org	Open access to 1.3 million e-prints in physics, mathematics, computer science, quantitative biology, quantitative finance, statistics, electrical engineering and systems science, and economics.
Educational Resources Information Center (ERIC)	eric.ed.gov	Covers education research and information for educators, researchers, and the general public. Enables searching for peer review only and full text availability.
Mendeley (Elsevier)	www.mendeley.com/research-papers	A free reference manager and academic social network.
Organic Eprints	orgprints.org	Open access archive for papers and projects related to research in organic food and farming.
Penn State's CiteSeerX	citeseerx.ist.psu.edu	Focused primarily on the literature in computer and information science.
PubMed	www.ncbi.nlm.nih.gov/pubmed	More than 28 million citations for biomedical literature from MEDLINE, life science journals, and online books.
Social Science Research Network	www.ssrn.com/en	SSRN´s eLibrary provides 0.7 million research papers across 30 disciplines.
U.S. government's Science.gov	www.science.gov	Covers 60 databases and over 2,200 scientific websites to provide full access to more than 200 million pages of U.S. federal science information.

content. Scholars without access to pay walled literature also can:

1) directly request copies of papers from the authors via email,
2) request from others in the academic community that do have access using the Twitter hashtag #icanhazpdf,
3) acquire articles through various torrents, Library Genesis, openaccessbutton.org, or on the anonymous website Reddit/r/scholar.
4) attempt interlibrary loans (at some institutions pdf scans are provided).

Providing legal open access preprints authors can take advantage of the often dramatic increases in citations for open access articles (Antelman, 2004; Harnad & Brody, 2004, Niyazov, et al., 2016). Thus, there is already an incentive to encourage scholars to share their work. Online open access journals provide wide exposure for authors, which are using publishing there at an increasing rate. For example, researchers access and download articles from *Practical Assessment, Research & Evaluation* (PARE) from all over the world daily (see data available on http://pareonline.net/). Not all of the literature, however, is open access nor accessible in the databases and by the techniques listed above. In some cases to access seminal papers, which must be read, reviewed and referenced for a complete literature review, scholars must gain access through paid databases. This can be particularly challenging for researchers not affiliated with a large organization, from developing countries and those that conduct research at teaching universities. The latter, for example, often conduct research on teaching, learning and pedagogy, but lack access to the full literature through their schools and dedicated funding for purchasing access.

A neuroscience scholar from Kazakhstan in this situation without adequate funding, was frustrated with lack of access and founded Sci-Hub, the world's largest pirate site for academic papers (at least 50 million) (Bohannon, 2016). Sci-Hub has been sued a number of times and continues to change its url. Interestingly, critics of Sci-Hub in *Science* have complained that many users can access the same papers through their libraries legally, but turn to Sci-Hub for convenience (Bohannon, 2016). Clearly, there is a need for a legal and convenient method to gain full access to all of the literature for all scholars. Fortunately, funding agencies are now also demanding open access posting and there has been a call for such organizations to begin directly sponsoring and publishing open access articles (Pearce, 2016). For example, since 2009, the NIH has demanded that all research they fund "*submit or have submitted for them to the National Library of Medicine's PubMed Central an electronic version of their final, peer-reviewed manuscripts upon acceptance for publication, to be made publicly available no later than 12 months after the official date of publication.*"(NIH, 2018). India's (Chawla, 2014), Portugal's (Carvalho, et al., 2017), Denmark's and some of Europe's (DTU, 2018) major science funders have done the same. The rational funding agencies use for this demand is that the public has already paid for the research through tax funding should be able to access the results for free. Private foundations are also moving in this direction of requiring open access such as the Gates Foundation (Van Noorden, 2014). Most of the major conventional publishers also maintain some legal and allowed form of preprint publishing so it is within reason to assume that in the near future the majority of literature will be available open access and discoverable by the databases shown in Table 1.

Literature Review Steps

Managing the literature can be done completely electronically using FOSS and will be covered in detail in the next section. Although the core process is of performing a literature review this way is the same as the historical method accomplished largely in hardcopy format the conventional process is enhanced. With FOSS literature reviews can be executed faster, be more complete, portable and potentially collaborative.

This section will briefly cover the steps in performing a high-quality literature review. First, using the academic search engines shown in Table 1 the literature review can occur. For researchers new to a field, one of the best ways to get started is to find recent review articles or major studies on the subject of interest. Next the researcher should read them and then 1) read the papers in the reference list from the review papers backwards in time and 2) read articles that cite the reviews forward in time, to populate their own literature review. Care should be taken to ensure that any information taken from review articles is not secondary (i.e. only primary sources should be cited after having read them). In addition, these literature review article are normally out of date (because of the rapid rate of technical progress) as well as they might have been

biased or poorly done. Thus, the researcher can continue by taking a systematic approach to searching the literature both backwards and forwards in time. Going backwards not only should the papers referenced be reviewed, but the author's names and the keywords in those papers can also be used. This can be repeated for a second level backwards (e.g. looking at the references, referenced in the papers originally referenced in the review article) or more depending on the depth necessary for the review (Levy & Ellis, 2006). Similarly, going forward if new authors cite the review articles then individual searches can be run on these authors. To accelerate the process the corresponding authors names on a collaborative paper are the most valuable to search as they normally represent the senior researcher and the one with the longest literature record.

Although all sources should be covered, researchers should focus primarily on the peer-reviewed literature. Often there may be key information that is not available yet in the peer-reviewed literature (e.g. new commercial technologies) and such sources can be used, but caution is necessary to ensure bias is not introduced (and it should be noted that corporate sponsorship can impact any literature). Thus, the use of non-peer-reviewed articles (e.g. technical journals, trade magazines, blogs, or newspapers) should be restricted to factual information. In addition, for some fields it may also be important to search through the patent databases (e.g. USPTO patent database, Espacenet, or Google Patents). In addition, researchers may want to limit their searches to an open source database and website that provides only inactive patents, which are in the public domain (Nilsiam & Pearce, 2016). This type of search can be accessed at http://freeip.mtu.edu/ made available by Michigan Technological University. Researchers must be extremely careful with the use of patents in literature reviews, as there is both a clear economic conflict of interest and patent applications do not go through the rigor of peer review. They are essentially legal documents made up of claims reviewed by the patent office for novelty and non-obviousness. Thus, all the writing in a patent that is not a claim does not necessarily have academic merit (e.g. similar to a blog post, anyone can write anything in the text of a patent). Literature of quality levels in between these two types of sources such as non-peer reviewed conference proceedings can also be used with caution with the reviewers themselves needing to judge carefully the quality and reliability of the work. Finally, all sources including those published in the peer-reviewed literature should be critically analyzed before accepting another researcher's findings and interpretations as valid to be included in the review.

If errors are made at this stage of gathering the relevant literature with the choice of keywords the results can be of poor quality or irrelevant. Thus, researchers should strive to use as many synonyms and alternative ways of expressing keyword or key phrases when using the search engines in Table 1. It is also useful to search with quotation marks around short phrases to ensure the most relevant literature is provided first. In general, broader and more generalizable terms will capture a wider range of the literature and should be used initially. In addition, care must be taken to look beyond temporarily popular buzzwords that have a short lifetime in the literature. The theories underlying the buzzwords have a longer life (Robey et al. 2000). Gathering all of the previous literature relevant to a specific area of scholarship is challenging. To determine if the literature is relevant, the entire electronic record does not need to be initially read. Randolph recommends eliminating most likely irrelevant studies using just the title and abstract (2009). Finally, the end of the search is indicated when additional searches provide no new citations and articles cited in the most-recently-discovered literature have already been included in the review.

After all of the literature has been found, it must be read and the data contained in the articles processed into information that can serve as a foundation for new research (Bem, 1995). Following the guidelines for organizing the literature review on a wiki (detailed below) entails making a bullet point notes of useful information for the project from each article included in the review. The bullet list can include any information that either summarizes the article or is useful for the researcher. As this information is being posted on the open web, it is recommended that incomplete sentences be used to record the thoughts while protecting against self-plagiarism when using the thoughts in writing a new manuscript as many publishers now use automatic plagiarism detection software.

FOSS Tool Chain for Literature Reviews

In order to reduce the time and economic investment needed to do a modern digital literature review all proprietary (closed source) and costly software can be avoided. A complete FOSS tool chain can be used for creating literature reviews in which case the researchers maintain complete control over their data

and always have access to the software needed to access, alter or build upon it. This FOSS software has zero capital costs and is made up of: 1) an operating system, 2) web browser, 3) reference organizer/database, 4) open access enabler software, 5) text editor/typesetter, and 6) sharing and collaboration software.

The most popular type of FOSS operating system is the GNU Linux operating systems (Stallman, 1997), which support all architectures, are highly reliable and have a zero cost. There are more than 100 distributions, with the most popular being Mint, Manjaro, Ubuntu, Debian, Solus, Elementary, Antergos and Fedora (Distrowatch, 2018), all of which can be downloaded and installed for free on existing computers of any type.

Linux distributions generally come with a FOSS web browser and the most popular is Firefox (Devčić, 2015). Firefox (Mozilla, 2018) has two available plugins, which are particularly useful for literature reviews. First, unpaywall (2018) is a Firefox plugin that enables researcher to click a green tab on the side of the browser and skip the paywall on millions of peer-reviewed journal articles. This makes finding accessible copies of articles much more rapid that searching each database individually. Unpaywall is fast, free, and legal as it accesses many of the open access sites that are listed in Table 1. Second, Zotero (2018) operates as an Android App (and iPad/iPhone app), desktop program and a Firefox plugin. It is a free, easy-to-use tool to help researchers collect, organize, cite, and share research. It replaces the functionality of proprietary packages such as RefWorks, Endnote and Papers for zero cost. Thus, Zotero can auto-add bibliographic information directly from websites, or publishers pages. In addition, it can scrape bibliographic data off of pdf files. Notes can be easily added on each reference. Then finally, it can import and export the bibliography databases in all of the publishers' various formats. Researchers can thus export bibliographic information to paste into a document editor for a paper or thesis as well as wiki for dynamic collaborative literature reviews (discussed in the next section).

Finally, academic articles can be written conventionally with the free office suite LibreOffice (2018), which operates similarly to Microsoft's Office products. Zotero has a word processor plugin to integrate directly with LibreOffice. LibreOffice is more than adequate for the vast majority of academic paper writing. In addition, researchers can take the writing of their papers one step further with LaTeX (2018), a high-quality typesetting system specifically designed for the production of technical and scientific documentation. Zotero libraries can be directly exported to BibTeX files for use with LaTeX.

Lastly, a wiki can be used to facilitate a dynamic collaborative literature review. A wiki is a website that allows anyone to add, delete, or revise content directly using a web browser. MediaWiki (2018a) is a free software open source wiki package written in open source PHP (2018). MediaWiki is available for anyone to set up their own wikis. Researchers can (in decreasing order of complexity) 1) set up their own research group wiki with MediaWiki (2018b), 2) utilize wikis already established at their universities (e.g. wiki.aalto.fi at Aalto University in Finland or ist.mit.edu/wikis at MIT in the U.S.) or 3) use wikis dedicated to areas that they research. For example, several university research groups that focus on sustainability research use Appropedia (2018), which is setup for collaborative solutions in sustainability, appropriate technology, poverty reduction, and permaculture. Utilizing a wiki makes it easy for anyone in the group to keep track of the status of and update literature reviews both current and from prior years or researchers. It also easily enables multiple members of the group to collaborate on the literature review asynchronously. Most importantly, it also facilitates others outside of the research group to assist in making a literature review more complete, accurate and up-to-date.

Thus, the entire tool chain for literature reviews can be covered with the FOSS shown in Table 2.

Table 2. Free and open source software useful for literature reviews

Free and Open Source Software	Download URL
GNU Linux Distributions	https://distrowatch.com/
FireFox	https://www.mozilla.org/en-US/firefox/new/
Unpaywall	https://unpaywall.org/
Zotero	https://www.zotero.org/
LibreOffice	https://www.libreoffice.org/
LaTeX	https://www.latex-project.org/
MediaWiki	https://www.mediawiki.org/wiki/MediaWiki

Encouraging Collaboration With Dynamic Wiki-Based Literature Reviews

Historically performing a literature review has been a solitary process, where a single researcher scours familiar databases and resources to maintain a list of references and perhaps comments in a single document. This has some obvious flaws including: i) no individual is intimately familiar with all of the areas of inquiry that may pertain to a topic, nor do they have access to all of the literature, and ii) previously mentioned fracturing of the literature and inability of any search engine to comprehensively search the literature easily. An obvious solution to such problems is to encourage other researchers to collaborate on relevant literature reviews. This can be done by using an open source approach by developing literature reviews on wikis.

Wikis are well known to foster collaboration in general (Leuf & Cunningham, 2001; McAfee, 2006; Wagner, 2004) and in education in particular (Abdekhodaee, et al., 2017; Biasutti, 2017; Cilliers, L. 2017; Cole, 2009; Pearce, 2009; Wang & Turner, 2004). Wikis are easy to edit with a relatively shallow learning curve (e.g. a typical research student can master the basics of wiki markup in under 30 minutes), which enables new researchers to quickly begin making real contributions to the effort of the group. In past experiments using wikis for literature reviews (Pearce, 2012), multiple researchers were able to edit and thus improve a literature review at the same time or from different locations (e.g. different labs and offices). The collaborative advantages to this were useful as researchers could telecommute (e.g. work from home in a remote community or while traveling) and thus reduce commuting time (Denkenberger, et al., 2015) while still contributing as full members of the group. In addition, the use of an open edit wiki encourages others to assist in the research outside of the group. Examples routinely observed included of assistance from wiki users not affiliated with the research group: i) giving helpful comments on group research on the discussion tab of pages, ii) making grammar and spelling corrections, iii) adding content to the group's literature reviews, iv) adding categories and hyperlinking either to or within work that are group has made, which adds to the value and discover-ability of the work (Pearce, 2012). Open literature reviews arranged in this way are extremely effective for passing on knowledge to the next generation of student researchers, keeping up to date on background research and finding references to read when writing a paper. However, it should be noted that publishing a literature review on a wiki does not give academics (who need peer reviewed articles for tenure) credit for doing the review. The wiki is merely a means of facilitating collaboration towards a normally published review. For example, Figure 1 and 2 shows several screenshots of a wiki literature review for an economic review paper on the levelized cost of electricity of solar cells. Figure 1 shows a typical literature review page for a wiki. The FOSS wiki software automatically generates a table of contents when wiki markup is used. The webpage can be edited by clicking the "Edit" hyperlink directly in the web browser. Best practices encourages other researchers to assist with the literature review. The goals and basic definitions of the literature review are explained in the beginning and an entry is made for each article reviewed.

Note that in Figure 2, each reviewed article was placed in its own level thus both enabling a wiki generated table of contents for the top of the page, but also an individual "edit" hyperlink for each entry. The latter makes it easy for others to add short notes as bullet points. The entry includes full bibliographic detail along with a bulleted list of useful information found in the article. Bullet point summaries avoid self-plagiarism when writing the full peer-reviewed article.

The wiki example shown in Figures 1 and 2 was accessed tens of thousands of times directly on the website and was edited by researchers outside of the founding pages research group. This improved the quality of the literature review and it became a major contribution to the field. According to Google Scholar, the resultant peer-reviewed article generated from the literature review has been cited over 800 times. In addition, this dynamic literature review continues to be improved so that the next time a researcher needs a review of the subject it will provide a valuable tool for extending the work further.

Although using a dedicated group wiki provides more control over it, using an established wiki to host a group's literature reviews has several other advantages. First, it is easy to get started as creating a free account is less technically challenging than setting up a wiki on a researcher-owned or subscription-based server. Second, using an existing wiki provides immediate exposure to the existing wiki community as well as high rankings for search results. For example, as Appropedia is currently the largest wiki dedicated to appropriate technology and

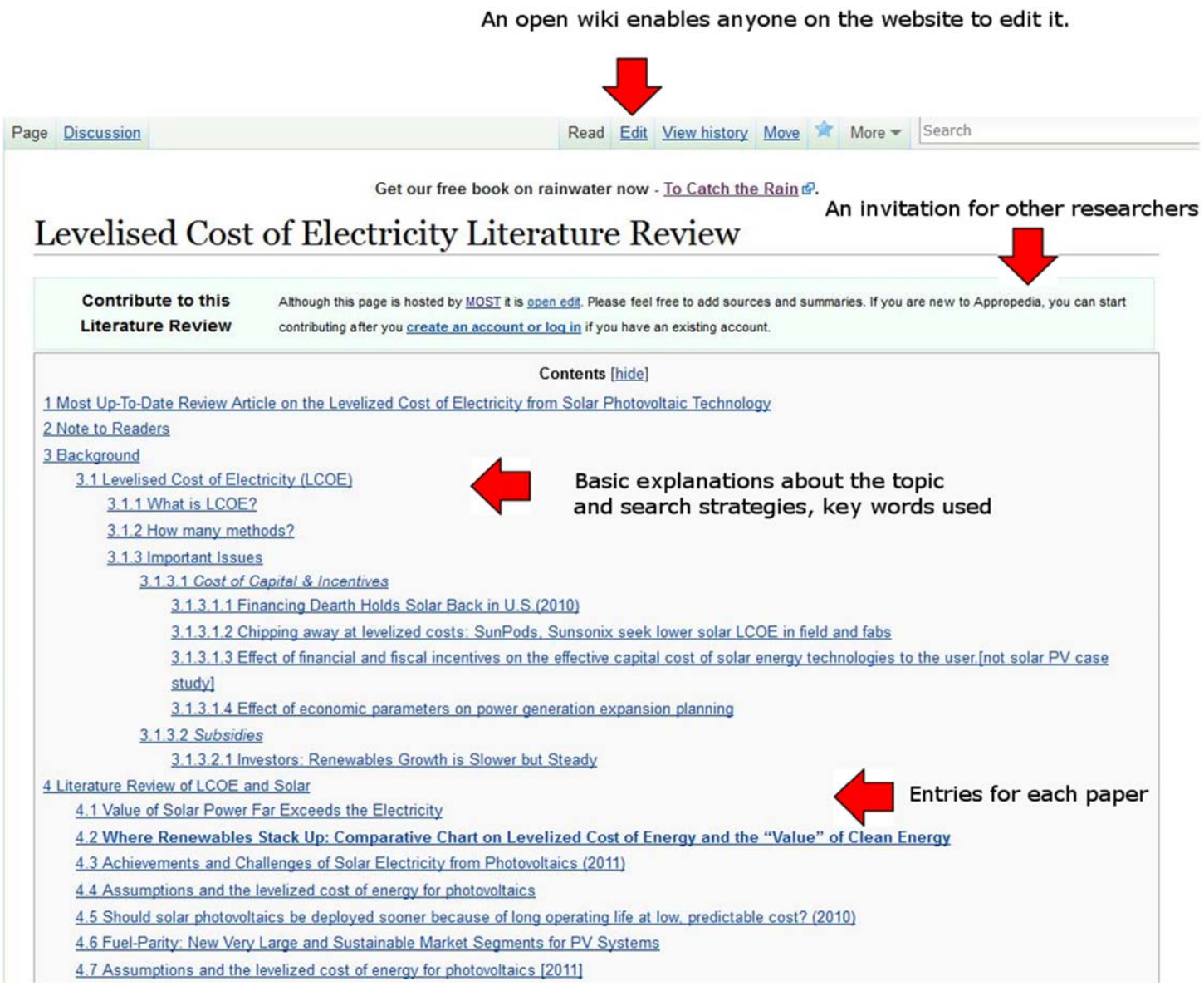

Figure 1. Typical literature review page on a wiki showing the top and table of contents.

Figure 2. An example short entry for an article on a wiki.

sustainability, the research group's that use it benefit from existing widespread global readership. This exposure can directly lead to funding opportunities (Pearce et al., 2012). In addition, to targeted wikis on a specific research topic, there are also generic open source research wikis that can provide the needs for nearly any discipline such as the semantic wiki for the sciences Open Research (2018).

Benefits to the Open Source Approach

The open source approach to developing literature reviews shown here has several benefits. First it reduces investment both in terms of researcher time and economic costs (both capital and operations). By using a FOSS tool chain the costs of proprietary software are eliminated, while at the same time using FOSS ensures that the literature databases created are not subject to changes in licensing agreements or discontinuing of software or support from a proprietary business. The risk of this occurring can be significant and FOSS protects researchers from this loss for any reason including bankruptcy, business decisions, sales or mergers, or the loss of key technical staff from proprietary vendors. Researchers can store a copy of the code themselves (or access it from freely available 3rd party repositories like GitHub, Bitbucket, Lauchpad, SourceForge, GitLab, GNU Savannah or OSDN). Thus, researchers have intellectual property control over the software used in every stage of their literature review as well as the database and output and can thus either solve any future problem with the FOSS themselves or pay others to do it. Researchers simply do not have these freedoms with proprietary software. Using, the list of freely accessible search engines and repositories as well as legal methods to access the peer-reviewed literature discussed above can save researchers significant time while also ensuring a comprehensive review of the literature. Finally, and perhaps most importantly, maintaining literature reviews in an open edit wiki enables others in the field to collaboratively improve them for both contemporary as well as future scholars.

Overcoming Problems with This Approach

This approach has numerous advantages besides low costs as discussed above. However, this approach also comes with challenges. This section will review challenges for each part of the open source approach and discuss method to overcome them.

Technical Computer Competency

Not all researchers are comfortable setting up Linux on their computers because of the technical challenges. First, it should be pointed out that this has become significantly easier over the last few years and that most computer users would be comfortable with the vast majority of the use of one of the easier distributions like Ubuntu. Second, most popular Linux distributions come with a 'try-before-you-buy' feature. For example, Ubuntu can be used from a bootable USB stick (Ubuntu, 2017). The USB stick allows researchers to test run the Ubuntu desktop experience without interfering in any way with their PC configuration. If the researcher likes the experience then the stick can be used to install Ubuntu on to their machine permanently. Researchers that previously purchased proprietary software they need (e.g. a simulation package, graphing package, etc.) can see if there is an open source alternative, using for example, osalt.com. If there is not an adequate alternative then it is possible to run the applications in Linux using either a remote Windows system, a virtual machine or Wine (2018). Wine, a recursive acronym for "Wine Is Not an Emulator", is a compatibility layer capable of running Windows applications on Linux. Even with these options moving to an open source operating system may be too difficult for some researchers. For them, a dual boot system that can use both Linux and Windows is recommended. Finally, it is not imperative to use Linux in order to be able to take advantage of the remainder of the software listed in Table 2. Thus, for example, Firefox and Zotero can be installed on a Windows machine. Installing and using all the remainder of the software is straightforward and researchers can get the help of their organization's IT staff for assistance. Because all of the software listed in Table 2 is zero cost, it should not represent a significant barrier for IT to install it on all of the computers at a university, nonprofit or company.

One Stop for Comprehensive Search and Access

Although the free (zero cost) academic search engines for published papers and preprints social networks have expanded significantly (Table 1), there is still a need for a one stop location for comprehensive academic article searching and open access finding. Håklev (2013) has argued that there is still a need for an open alternative to Google Scholar, although this does not preclude the current use of the many databases in Table 1. Future work is needed to reduce the time expenditure to utilize all of these resources.

Vandalism

A common fear among researchers about putting their work on an open wiki that anyone can edit is that it would be vandalized either maliciously or simply corrupted by well-intentioned users that alter their writing. Fortunately, there are several ways around this potential problem. First spam and actual vandalism on the major wikis, are normally removed by the vigilant team of administrators for the wiki without any effort from researchers. For smaller wikis (e.g. a research group's own wiki with only modest internet traffic) this is less of a problem because there is less of an incentive for bot-based advertising-funded spamming that makes up the vast majority of vandalism. Thus, small wikis can be passively defended. Researchers can add their literature review pages to their watchlists so that they can choose to be notified if it is edited by someone other than themselves. Vandalism can be easily removed with 1 or 2 clicks of "undo" from the standard revision "view history" menu of any Wikimedia-based page.

Critical Mass for Collaboration on Literature Reviews

To have the free user to user assistance seen in the success of FOSS (Lakhani & Von Hippel, 2003) there must be a critical mass of users. Thus, the primary challenge with the wiki collaboration approach is there must be a critical mass or other researchers external to a lab that use the same approach (e.g. are willing to contribute to a shared literature review) to obtain the full list of benefits. In a vibrant and well-populated open research community, which has reached critical mass on any research topic, maintaining a literature review would become a community affair and not the primary work of a single group. If the majority of researchers simply added their own work in order to garner more attention to it, this approach would be significantly improved. Future work is needed to determine the most effective methods for encouraging an entire research community to adopt the open source approach.

Conclusions

This paper has shown best practices for using a tool chain of free and open source software and methods to perform literature reviews. Resources for comprehensive searching and obtaining access to the literature were provided that enable researchers from underfunded labs and countries with low-levels of scientific financing to participate in the scientific enterprise. Free and open source software, was provided for all steps including browsing, bibliographic software, and writing. Finally, a clear framework was provided for documenting a literature review to encourage collaboration of a dynamic document that lives into the future for the benefit of all researchers in a given field. This approach was shown how to solve the current challenges of literature reviews in general and reduce time expenditures and costs. Finally, the challenges of using this approach are discussed and either overcome with existing methods or future work is provided. It is concluded, that although there are many types and goals of literature reviews, all of them can be improved using a tool chain of free and open source software and methods.

References

Abdekhodaee, A., Chase, A. M., & Ross, B. (2017). Wikis for group work: Encouraging transparency, benchmarking, and feedback. *Australasian Journal of Educational Technology*, 33(5).

Alexy, O., Henkel, J., & Wallin, M. W. (2013). From closed to open: Job role changes, individual predispositions, and the adoption of commercial open source software development. *Research Policy*, 42(8), 1325-1340.

Antelman, K. (2004). Do open-access articles have a greater research impact?. *College & Research Libraries*, 65(5), 372-382.

Appropedia. (2018). Retrieved April 5, 2018, from http://www.appropedia.org/Welcome_to_Appropedia

Årdal, C., & Røttingen, J. A. (2016). Financing and collaboration on research and development for nodding syndrome. *Health Research Policy and Systems*, 14(1), 19.

Baden, T., Chagas, A. M., Gage, G., Marzullo, T., Prieto-Godino, L. L., & Euler, T. (2015). Open Labware: 3-D printing your own lab equipment. *PLoS Biology*, 13(3), e1002086.

Devčić, I. I. (2015, March 30). Top 10 Best Web Browsers For Linux. Retrieved April 6, 2018, from https://beebom.com/best-web-browsers-for-linux/

Bem, D. J. (1995). Writing a review article for psychological bulletin. *Psychological Bulletin*, 118(2), 172-177.

Bettany-Saltikov, J. (2012). *How to do a systematic literature review in nursing: a step-by-step guide*. McGraw-Hill Education (UK).

Biasutti, M. (2017). A comparative analysis of forums and wikis as tools for online collaborative learning. *Computers & Education*, 111, 158-171.

Bohannon, J. (2016). Who's downloading pirated papers? Everyone. *Science*, 352(6285), 508-512.

Boldrin, M., & Levine, D. K. (2008). Against intellectual monopoly (Vol. 78). Cambridge: Cambridge University Press.

Boote, D. N., & Beile, P. (2005). Scholars before researchers: On the centrality of the dissertation literature review in research preparation. *Educational Researcher*, 34(6), 3-15.

Boudreau, K. J., & Lakhani, K. R. (2016). Innovation Experiments: Researching Technical Advance, Knowledge Production, and the Design of Supporting Institutions. *Innovation Policy and the Economy*, 16(1), 135-167.

Budgen, D., & Brereton, P. (2006). Performing systematic literature reviews in software engineering. In Proceedings of the 28th international conference on Software engineering (pp. 1051-1052). ACM.

Carvalho, J., Laranjeira, C., Vaz, V., & Moreira, J. M. (2017). Monitoring a national open access funder mandate. *Procedia Computer Science*, 106, 283-290.

Chawla, D.M. (2014) India's major science funders join open-access push. *Science*. Retrieved April 6, 2018, from http://www.sciencemag.org/news/2014/12/india-s-major-science-funders-join-open-access-push

Cilliers, L. (2017). Wiki acceptance by university students to improve collaboration in Higher Education. *Innovations in Education and Teaching International*, 54(5), 485-493.

Coakley, M., & Hurt, D. E. (2016). 3D Printing in the laboratory: maximize time and funds with customized and open-source labware. *Journal of Laboratory Automation*, 21(4), 489-495.

Cole, M. (2009). Using Wiki technology to support student engagement: Lessons from the trenches. *Computers & Education*, 52(1), 141-146.

Colombo, M. G., Piva, E., & Rossi-Lamastra, C. (2014). Open innovation and within-industry diversification in small and medium enterprises: The case of open source software firms. *Research Policy*, 43(5), 891-902.

Cooper, H. M. (1988a). The integrative research review: A systematic approach (No. 2). Sage Publications.

Cooper, H. M. (1988b). Organizing knowledge syntheses: A taxonomy of literature reviews. *Knowledge in Society*, 1(1), 104.

Deek, F. P., & McHugh, J. A. (2007). Open source: Technology and policy. Cambridge University Press.

Denkenberger, D., Way, J. and Pearce, J.M. Educational pathways to remote employment in isolated communities. *Journal of Human Security* 11(1) (2015): 34.

DiBona, C., & Ockman, S. (1999). Open sources: Voices from the open source revolution. " O'Reilly Media, Inc.".

Distrowatch. (2018) DistroWatch.com: Put the fun back into computing. Use Linux, BSD. Retrieved April 6, 2018, from https://distrowatch.com/

Dodourova, M., & Bevis, K. (2014). Networking innovation in the European car industry: Does the Open Innovation model fit?. *Transportation Research Part A: Policy and Practice*, 69, 252-271.

DTU (2018). Requirements from funders concerning Open Access publishing - DTU Library. Retrieved April 6, 2018, from http://www.bibliotek.dtu.dk/english/servicemenu/publish/openaccess/Requirements

Harnad, S., & Brody, T. (2004). Comparing the impact of open access (OA) vs. non-OA articles in the same journals. D-lib Magazine, 10(6).

Hart, C. (1998). *Doing a literature review: Releasing the social science research imagination*. Sage.

Harzing, A. (2017). Google Scholar is a serious alternative to Web of Science. Retrieved April 6, 2018, from https://harzing.com/blog/2017/02/google-scholar-is-a-serious-alternative-to-web-of-science

Håklev, S. (2013). An open alternative to Google Scholar. Retrieved April 5, 2018, from https://www.force11.org/presentation/open-alternative-google-scholar

Hawkins, R. E. (2004). The economics of open source software for a competitive firm. NETNOMICS: *Economic Research and Electronic Networking*, 6(2), 103-117.

Henkel, J., Schöberl, S., & Alexy, O. (2014). The emergence of openness: How and why firms adopt selective revealing in open innovation. *Research Policy*, 43(5), 879-890.

Hienerth, C., Von Hippel, E., & Jensen, M. B. (2014). User community vs. producer innovation development efficiency: A first empirical study. *Research Policy*, 43(1), 190-201.

Jesson, J., & Lacey, F. (2006). How to do (or not to do) a critical literature review. *Pharmacy Education*, 6.

Lakhani, K. R., & Von Hippel, E. (2003). How open source software works:"free" user-to-user assistance. *Research Policy*, 32(6), 923-943.

LaTeX (2018) LaTeX - A document preparation system. Retrieved April 6, 2018, from https://www.latex-project.org/

Leuf, B., & Cunningham, W. (2001). *The Wiki way: quick collaboration on the Web*.

Levy, Y., & Ellis, T. J. (2006). A systems approach to conduct an effective literature review in support of information systems research. *Informing Science*, 9.

Lewis, D. W. (2012). The inevitability of open access. *College & Research Libraries*, 73(5), 493-506.

LibreOffice (2018). Home | LibreOffice - Free Office Suite - Fun Project - Fantastic People. Retrieved April 6, 2018, from https://www.libreoffice.org/

Martinez, M. G. (2015). Solver engagement in knowledge sharing in crowdsourcing communities: Exploring the link to creativity. *Research Policy*, 44(8), 1419-1430.

McAfee, A. P. (2006). Enterprise 2.0: The dawn of emergent collaboration. *MIT Sloan Management Review*, 47(3), 21.

MediaWiki. (2018a). Retrieved April 5, 2018, from https://www.mediawiki.org/wiki/MediaWiki

MediaWiki. (2018b) Manual:Installation guide - MediaWiki. (n.d.). Retrieved April 6, 2018, from https://www.mediawiki.org/wiki/Manual:Installation_guide

Mozilla (2018) Download the fastest Firefox ever. Retrieved April 6, 2018, from https://www.mozilla.org/en-US/firefox/new/

NIH (2018). NIH Public Access Policy Details | publicaccess.nih.gov. Retrieved April 6, 2018, from https://publicaccess.nih.gov/policy.htm

Nilsiam, Y., & Pearce, J. M. (2016). Open source database and website to provide free and open access to inactive US patents in the public domain. *Inventions*, 1(4), 24. doi:10.3390/inventions1040024

Niyazov, Y., Vogel, C., Price, R., Lund, B., Judd, D., Akil, A., ... & Shron, M. (2016). Open access meets discoverability: Citations to articles posted to Academia. edu. *PloS One*, 11(2), e0148257.

OpenResearch. (2018). Retrieved April 6, 2018, from http://openresearch.org/Main_Page

Pearce, J. M. (2009). Appropedia as a tool for service learning in sustainable development. *Journal of Education for Sustainable Development*, 3(1), 45-53.

Pearce, J. M. (2012). Open source research in sustainability. *Sustainability: The Journal of Record*, 5(4), 238-243.

Pearce, J. M., Babasola, A., & Andrews, R. (2012). Open solar photovoltaic systems optimization. In *Proceedings of Open, the Annual National Collegiate Inventors & Innovators Alliance Conference*.

Pearce, J. M. (2013). *Open-source lab: how to build your own hardware and reduce research costs*. Elsevier.

Pearce, J.M. (2015a) Quantifying the Value of Open Source Hardware Development. *Modern Economy*, 6, 1-11. doi: 10.4236/me.2015.61001

Pearce, J. M. (2015b). Return on investment for open source scientific hardware development. *Science and Public Policy*, 43(2), 192-195.

Pearce, J. M. (2016). Funding Universal Open Access via Academic Efficiency Gains from Government Funder Sponsored Open Access Journals. *Ariadne*, (76). http://www.ariadne.ac.uk/issue/76/pearce

Pearce, J.M., (2017). Emerging Business Models for Open Source Hardware. *Journal of Open Hardware*. 1(1), p.2. DOI: http://doi.org/10.5334/joh.4

Petch, A., Lightowler, C., Pattoni, L., & Watson, I. (2014). Embedding research into practice through innovation and creativity: a case study from social services. Evidence & Policy: *A Journal of Research, Debate and Practice*, 10(4), 555-564.

Petersen, E. E., & Pearce, J. (2017). Emergence of home manufacturing in the developed world: Return on investment for open-source 3-D printers. *Technologies*, 5(1), 7. doi:10.3390/technologies5010007

Petersen, E. E., Kidd, R. W., & Pearce, J. M. (2017). Impact of DIY Home Manufacturing with 3D Printing on the Toy and Game Market. *Technologies*, 5(3), 45; doi: 10.3390/technologies5030045

PHP: Hypertext Preprocessor. (2018). Retrieved April 5, 2018, from http://www.php.net/

Piwowar, H., Priem, J., Larivière, V., Alperin, J. P., Matthias, L., Norlander, B., … Haustein, S. (2017). The State of OA: A large-scale analysis of the prevalence and impact of Open Access articles (No. e3119v1). *PeerJ Inc.* https://doi.org/10.7287/peerj.preprints.3119v1

Randolph, J. J. (2009). A guide to writing the dissertation literature review. *Practical Assessment, Research & Evaluation*, 14(13), 1-13.

Raymond, E. (1999). The cathedral and the bazaar. *Knowledge, Technology & Policy*, 12(3), 23-49.

Riehle, D. (2007). The economic motivation of open source software: Stakeholder perspectives. *Computer,* 40(4).

Robey, D., Boudreau, M. C., & Rose, G. M. (2000). Information technology and organizational learning: a review and assessment of research. Accounting, Management and Information *Technologies*, 10(2), 125-155.

Söderberg, J. (2015). *Hacking capitalism: The free and open source software movement (Vol. 9)*. Routledge.

Sample, I. (2012). Harvard University says it can't afford journal publishers' prices. *The Guardian*, 24, 2012.

Shaw, D. (1995). Bibliographic database searching by graduate students in language and literature: Search strategies, system interfaces, and relevance judgments. *Library & Information Science Research*, 17(4), 327-345.

Stallman, R. (1997). Linux and the GNU Project. Online Document, 2006. gnu.org. Retrieved April 6, 2018, from https://www.gnu.org/gnu/linux-and-gnu.en.html

Ubuntu (2017, July 18). Create a bootable USB stick on Windows | Ubuntu tutorials. Retrieved April 6, 2018, from https://tutorials.ubuntu.com/tutorial/tutorial-create-a-usb-stick-on-windows

Unpaywall. (2018) Unpaywall. Retrieved April 6, 2018, from https://unpaywall.org/

Van Noorden, R. (2014). Gates Foundation announces world's strongest policy on open access research : *Nature News blog*. Retrieved April 6, 2018, from http://blogs.nature.com/news/2014/11/gates-foundation-announces-worlds-strongest-policy-on-open-access-research.html

Wagner, C. (2004). Wiki: A technology for conversational knowledge management and group collaboration. *The Communications of the Association for Information Systems*, 13(1), 58.

Wang, C. M., & Turner, D. (2004). Extending the wiki paradigm for use in the classroom. In *Information Technology: Coding and Computing, 2004. Proceedings* (Vol. 1, pp. 255-259). IEEE.

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly*, xiii-xxiii.

WineHQ - Run Windows applications on Linux, BSD, Solaris and macOS. (2018). Retrieved April 23, 2018, from https://www.winehq.org/

Wittbrodt, B. T., Glover, A. G., Laureto, J., Anzalone, G. C., Oppliger, D., Irwin, J. L., & Pearce, J. M. (2013). Life-cycle economic analysis of distributed manufacturing with open-source 3-D printers. *Mechatronics*, 23(6), 713-726.

Woern, A. L., & Pearce, J. M. (2017). Distributed Manufacturing of Flexible Products: Technical Feasibility and Economic Viability. *Technologies*, 5(4), 71.

Zhu, K. X., & Zhou, Z. Z. (2012). Research note—Lock-in strategy in software competition: Open-source software vs. proprietary software. *Information Systems Research*, 23(2), 536-545.

Zotero (2018). Zotero | Your personal research assistant. Retrieved April 6, 2018, from https://www.zotero.org/

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